M2 Research internship – 2015

Estimation of the photometric properties for digitized 3D objects acquired in uncontrolled lighting conditions

Duration: 6 months / **Funding:** About 520 euros per month, net salary

Host team: IGG (Computer Graphics and Geometry group) at ICube Lab

Advisors: Jean-Michel Dischler (dischler@unistra.fr)
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Prerequisites: Computer Graphics, image processing, geometric modeling, C++ programming

Fig. 1 – Photograph of a real object and realistic rendering of a reconstructed geometric model that reproduces the appearance of this object from the same point of view (pictures from [VSG+13]).

Context and problem statement

Current 3d digitization technologies for real objects considerably simplify the process of creating 3d models, especially for the digital content production industry (video games, virtual museography, e-business, etc.). In this context, for reasons of cost-effectiveness, it is desirable that the acquisitions be performed with the "lightest" possible equipment and with only few constraints, especially regarding the lighting conditions. Today's techniques for reconstructing geometry from samples obtained from 3d scans or collections of photographs are very reliable. To be able to render digital models in a realistic way, it is required to adopt robust methods to estimate the photometric properties of the surface of the objects. The possibility to render scenes with lighting environments that differs from the conditions of the acquisition should also be offered.

For several years now our group has been developing a 3d digitization platform for real objects including both geometry and appearance acquisition and processing [PNIGG]. It aims at providing a complete set of automatic tools for the production of detailed geometric models [Lar08] as well as the reconstruction of the photometric properties of the surface of the objects from photographs in the form of surface light fields [VSG+13] (Fig. 1). A surface light field only depends on the direction of the point of view, and hence does not make it possible to visualize a reconstructed model in a lighting environment that differs from the one of the acquisition.

In order to perform realistic rendering with variable lighting conditions, the common approach consists in estimating the parameters of a Bidirectional Reflectance Distribution Function (BRDF) model that characterizes the optical properties of a material, with respect to the direction of the point of view and the directions and intensities of the light sources, possibly taking spatial variations into consideration (i.e. Spatially Varying BRDF, or SVBRDF) [LKG+01]. Most existing methods for the estimation of the parameters rely on photometric acquisitions performed in perfectly controlled lighting environments. When the lighting environment is controlled, the estimation of specularity is in particular made easier. This property depends on both the direction of the point of view and the directions of the light sources. Palma et al. [PCD+12] are among the first authors to propose a method for the reconstruction of an approximate SVBRDF in uncontrolled, but fixed lighting conditions. This method however has several limitations: the estimation of the specularity remains inaccurate; the classification of the materials only takes into account the variation of the diffuse color (for example, the variations of the geometry, or the presence of shadows are not taken into account). Currently there is no method to estimate photometric properties in uncontrolled lighting conditions that is sufficiently reliable and robust.

Internship goal

The first objective of this internship is to perform an exhaustive evaluation of the method proposed by Palma et al. [PCD+12] for the estimation of the photometric properties of the surface of a digitized object. After having estimated the directions and intensities of the light sources, as a first step, the diffuse and specular components of the various materials of an object will be calculated using the Phong model with spatial variations as proposed by the authors. The method, which was initially developed for video sequences as input data, will have to be adapted to take photographs. The latter offer a higher resolution at the cost of a loss of spatial coherency. The implemented algorithms will be tested on the data sets of the IGG group, especially on pieces of artwork, as well as on synthetic data sets serving as ground truth. The second objective of the internship will be to propose an improvement of the estimation of the photometric properties, e.g. by using a more complex BRDF model like the Lafortune model, by relying upon the work by Lensch et al. [LKG+01]. The implementation will be done in C++ and will be part of the digitization platform of the IGG group.

References

[Lar08] F. Larue. Numérisation de Pièces d’Art en termes de Forme et d’Apparence pour la Visualisation Réaliste en Synthèse d’Images. Thèse de Doctorat en Informatique, LSIIT CNRS - Université Louis Pasteur, Strasbourg, France, 2008.

[LKG+01] H. P. A. Lensch, J. Kautz, M. Goesele, W. Heidrich, H.-P. Seidel. Image-Based Reconstruction of Spatially Varying Materials. Proc. Eurographics Workshop on Rendering Techniques, pages 103-114, 2001.

[PCD+12] G. Palma, M. Callieri, M. Dellepiane, R. Scopigno. A Statistical Method for SVBRDF Approximation from Video Sequences in General Lighting Conditions. Computer Graphics Forum (Proc. Eurographics Symposium on Rendering 2012), 4(31):1491-1500, 2012.

[PNIGG] IGG’s Digitization Platform: http://icube-igg.unistra.fr/en/index.php/Digitization

[VSG+13] K. Vanhoey, B. Sauvage, O. Génevaux, F. Larue, J.-M. Dischler. Robust fitting on poorly sampled data for surface light field rendering and image relighting. Computer Graphics Forum, 32(6):101-112, 2013.